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A NEW CONCEPTUAL SUSTAINABLE WATER RESOURCES RESEARCH

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ABSTRACT

A paradigm about the water resources management is changing the operation management to the nation water security. At this stage, the sustainable water resources are a matter of great interest. There are many methods to secure the water resources. Among others, constructing a dam is direct and active**.** In the Korea, however, the dam construction is more and more difficult because of the decrease of a suitable location, the opposition of community Residents and environment group and negative public opinion. Therefore, a new conceptual Multipurpose Regulating Dam is suggested in the present paper. The Multipurpose Regulating Dam can provide securing water resources, flood control, hydroelectric power, eco-environmental in stream flow and recreation as well as the use of function of existing dam. The Multipurpose Regulating Dam saves the construction and compensation costs due to the use of conventional river channel, and has an advantage economically. Also, it will improve negative eyes from the local residents. The research sequence introduces basic concepts for the Multipurpose Regulating Dam construction, and the propriety Evaluation, the decision of dam type and the verification of operation rule are approached sequentially. The verification is applied to Yeong Cheon Dam (water supply only) in the Korea. The appropriate operation scenario is selected after establishing the various scenarios by HEC-Ressim modeling. The results show securing water resources of 14 million ton and the flood control of 15.4 million ton in comparison with solo operation of existing dam. If the current research is advanced and continuous, it will be a good alternative as new water management method.

KEYWORDS: Eco-Environmental in stream Flow, Flood Control, Hydroelectric Power, Multipurpose Regulating Dam, Water Resources

INTRODUCTION

To cope with and adapt to various water-related disasters in response to the crisis according to climate change is a common concern of all countries (UNWWDR 4, 2002). In last June 2013, Ganges River and its branch were flooded due to localized heavy rains in the Hindustan (northern area of India), and more than 5,000 people were killed or disappeared caused by the occurrence of large-scale landslide. Also, it was estimated that in November of that year, while the Philippines were hit hard by a super typhoon ‘Haiyan’, approximately 8,000 casualties were occurred, whereas, since a drought was deepened due to a record-heat wave in China, over 600 million people in 13 castles such as Hunan suffered from a drinking water shortage, and the economic loss of about 940 billion won, such as the crops damage was occurred. Thus, if water is excessive or deficient, it gives much damage to human. However, because the available water resources have the restriction of time and space, the preserved amount of water is limited. Therefore, the establishment of the response measures in accordance with a climate change, leading to the increase of the intensity and incidence frequency of flooding and drought, at the same time the that distribution of the sufficient water is conducted by maximally utilizing the

available water resources is essential. In fact, the most direct and positive method is to secure the water resources by means of the structures such as a dam, a dammed pool for irrigation, and Estuary Bank. In order to compensate the temporal and spatial imbalance of water resources, most of methods are compensating the water shortage of a period of water shortage by adjust the peak discharge and by storing the surplus water resources, using a dam in a flood season (Chung et.Al, 2010).

But in the Korea these methods require the long period from planning to construction, and need the selection of the right place for construction, and suffer from the opposite of many environmental groups and the local residents owing to the large-scale civil engineering projects. In addition, if exceeding the marginal capacity of the structure, there is also the case that the utility becomes a dead dog. Even though this drawback, many countries around the world are securing still the water resources through the methods by the various structures, such as dams and barrage, and that is to say, it indirectly shows the point that these methods are the most effective than other alternatives. But the reality is faced with a very difficult situation to build a large dam. First, it is the tendency that the suitable places to build a dam are gradually decreased, and because the negative perception of local residents or environmental groups, and the public opinion against the large structures (particularly, dam) for water resources are very strong, and the problem losing hometown, and the cultural property issues along with astronomical compensation amount should be solved, it is the difficult situation to promote the business. Therefore, to develop the water resources projects, the improvement direction should be sought based on the current situation diagnosis.

Therefore, the current study proposed a new conceptual “Blue Reservoir”. Accordingly, first, the authors have established the definition of the Blue reservoir, and they have suggested the matters, operation and the application method of model that shall be considered to install the Blue reservoir, and they have also presented the results apply ng it to the actual river basin through a case study.

THE DEFINITION OF BLUE RESERVOIR

The Blue reservoir is basically installed in online at the channel in the direct downstream of the dam having various purposes such as a multipurpose dam, water supply dam, and a hydroelectric dam. In other words, it has the similar form to the existing balancing reservoir dam. But there are many differences between the Blue reservoir and the existing balancing reservoir. The existing balancing reservoir played a role that evenly discharges it to the downstream over 24 hours after storing the water discharging through the Peak-load power at the multipurpose dam and hydroelectric dam. Whereas a Blue dam provides the water bowl for the security of the water resources in the watershed along with flood control effect by utilizing the discharge flow of the flood period meaninglessly flowing to downstream. Also the Blue dam can uniformly discharge the flow rate for ecological environment preservation to the downstream beyond the concept of the flow rate for maintaining a river, and it can help for the restore integrity of a river and the safety security of ecosystem by preventing the cold-weather damage. And it has many right functions that the demand and supply through self-electrical generation is possible and can use also the stored water for the local recreation, and it has the advantage that can establish its own operation rules by reflecting the operation rules of the existing dam. Above all, the Blue dam has the advantage that can minimize the environmental damage, because the construction costs become cheaper and the construction period can be shortened by utilizing the existing channel as it is. Wolff and Gleick(2002) have suggested that will provide potentially very positive opportunity if the harmony with nature is formed by using the dam that the environment is not almost damaged. Furthermore, it is expected that the Blue dam can present the solutions for large water structure with the opposite of the environmental groups and the local residents, and the social negative perception due to the loss of hometown and

compensation issues, and the cultural property issues, and it is considered that it will be the good alternative in the current situation that the right place of a dam is gradually decreased.

RESEARCH AREA

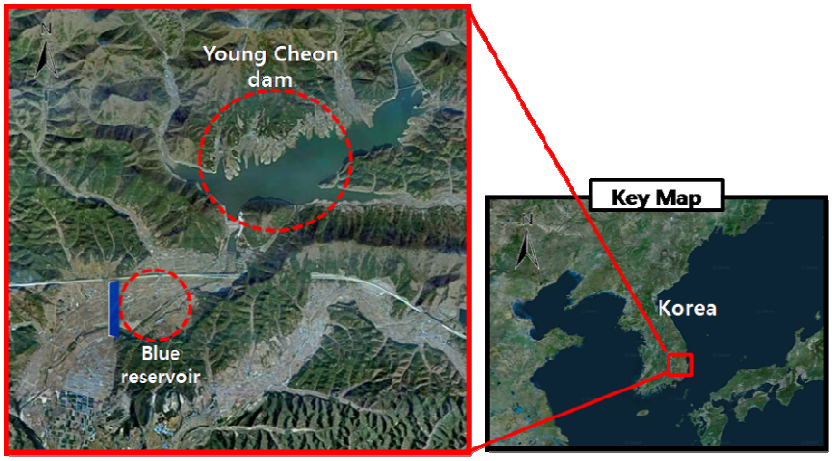


Figure 1: Study Area

In this study, the Blue reservoir was installed in the downstream of Yeongcheon dam which is a water supply dam located at the riverside of Geumhogang River in Gyeongsangbuk-do as shown in Figure 1.

The Yeongchen dam is located at Jayang-myeon in Yeongcheon-si, Gyeongsangbuk-do, the height of the dam is 42m, the length is 300m, and total storage capacity is 96.4 million m^3, This dam was constructed for the purpose of industrial and domestic water supply, and the irrigation water and river maintenance water supply for the downstream area of the dam. In addition, unusually the Yeongcheon dam is using the water supplied from Imha dam located in the other river basin, and supply water through a raceway to other region, and is producing the electricity of 6GWh at the small hydraulic plant with the station capacity of 1 MW.

THE RESEARCH PROCESS

The installation technique of Blue reservoir proposed in this study consists of the validation steps such as the evaluation of installation possibility, the capacity and operation decision, and its flow chart is shown in Figure 2.

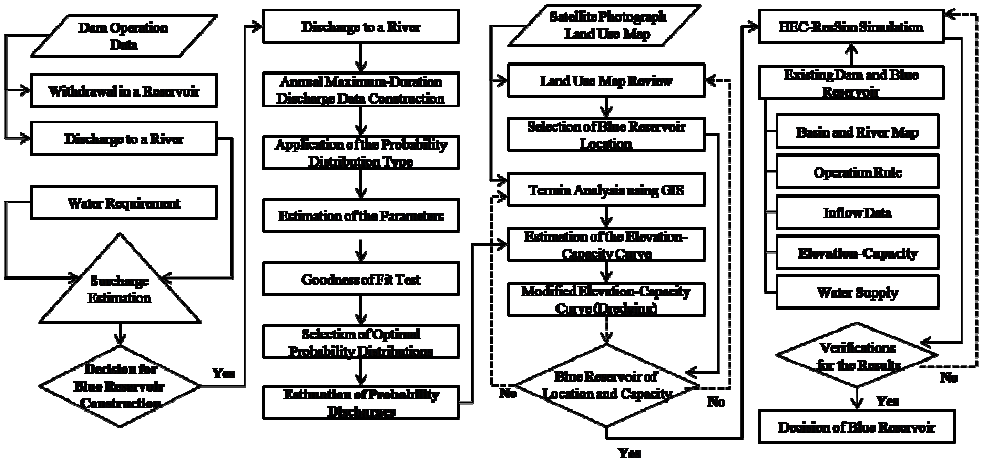


Figure 2: The Technique for Building the Blue Reservoir

Whether the installation is possible should be determined by conducting the evaluation for the security of water quantity if the Blue reservoir will be installed at the downstream of the dam.

In other words, it is evaluated by calculating the water quantity discharged in excess in flood seasons.

The position of the Blue reservoir must determine by considering the aerial photograph and the land utilization, and the capacity of the reservoir is decided by quantitatively presenting through the hydrologic statistic techniques targeting the morphological analysis through GIS (geographic information system) and the flow rate directly discharged from the original dam into the river.

The storage capacity of the Blue reservoir and the operation rules are finally determined by reviewing whether the improvement of the river flow condition in the Blue reservoir and the increase of additional water quantity for electricity generation are possible, while maintaining, as it is, the water supply and the electricity discharge of the original dam through a simulation.

INSTALLATION GUIDE OF BLUE RESERVOIR

As a result comparing the annual water supply and the operating performance data, it was analyzed that the security of water of 133M ㎥ per year is possible as shown in Figure 3.

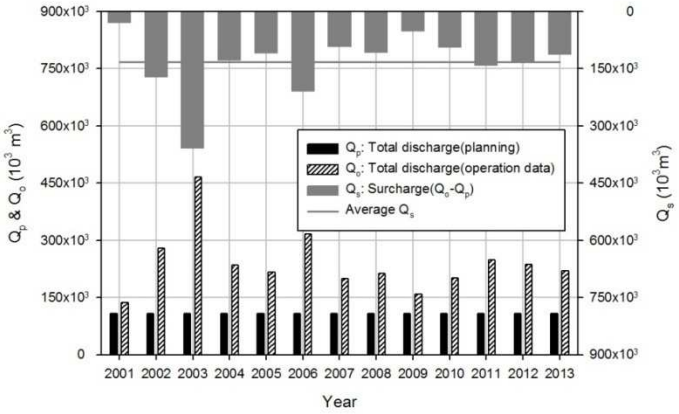
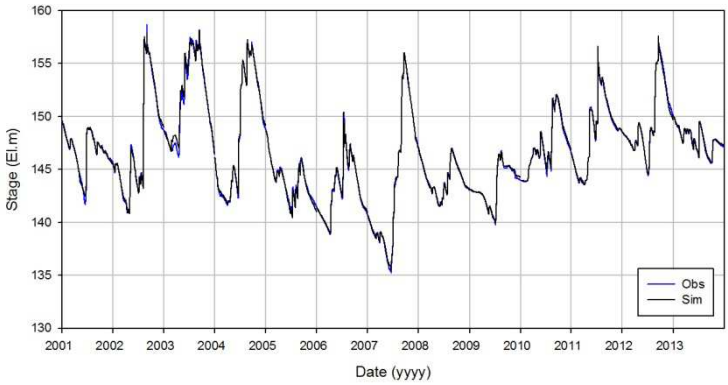


Figure 3: An Analysis of Securing Available Water Resources

The annual maximum discharge per the duration among the discharge flow discharged from the original dam into the river is consisted as the input data, and the probability discharge per the frequency-duration was calculated through the process such as the basic statistics, preliminary analysis, parameter estimation and the goodness of fit test. In this study, in order to calculate the optimum storage capacity by considering the amount of dredging, the water level-storage capacity curves of 30.4, 34.8, and 39.8 M ㎥ corresponding to the duration of 7 days for 100-year frequency, the duration of 6 days for 200-year frequency, respectively, and the duration of 10 days for 200-year frequency were calculated.

The Blue reservoir's effects are analyzed by using HEC-ressim model. The water level (Daily) of the reservoir among the operation performance data of the original dam was designated as a calibration target, and its period is from 2001 to 2013. The spill occurred in the dam basin and the inflow (Daily) through the raceway are the upstream boundary conditions, and the water supply and the electricity discharge are the downstream boundary conditions, and the water level of the original dam was calibrated by the overtropping discharge through the sluice, that is, a parameter. The

electricity discharge and the water supply were built as input data, and the model was calibrated with the discharge flow by the gate operation as the parameter. The observations of the original dam and the simulated hydrological curve are the same as Figure 4. As a result conducting the linear regression analysis using this result, the coefficient of determination was analyzed as 0.9977 (Figure 5).



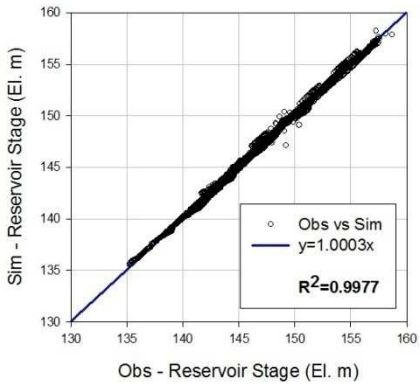


Figure 4: Comparison of the Observed and Simulated Data **Figure 5: Linear Regression Analysis**

The Blue reservoir is focused on whether the original dam can additionally supply the water for river maintenance and the water quantity for electricity generation by securing the excessive flow rate of the downstream while maintaining the operation of the dam, as it is. In order to determine the most ideal capacity and the additional discharge, 12 scenarios were composed as shown in Table 1.

Table 1: Scenarios for the Blue Reservoir

Scenario No.	Frequency & Duration	Blue reservoir Capacity (M㎥)	Additional downstream discharge plan
1	100-year 7-day	30.45	+ 10%
2			+ 20%
3			+ 30%
4			+ 40%
5	200-year 6-day	34.79	+ 10%
6			+ 20%
7			+ 30%
8			+ 40%
9	200-year 10-day	39.78	+ 10%
10			+ 20%
11			+ 30%
12			+ 40%

The flow-duration variability was reviewed by year in order to determine the optimal volume and operation of the Blue reservoir, and low flow (Q533) of scenario 9 that added 10% was determined since the scenario can provide the additional water supply in comparison with other scenario also in 2008, 2009 and 2010 corresponding to the drought year. To compare with the installation effect of Blue reservoir, the result of unilateral operation of Yeong Cheon Dam and the scenario 9 simulation result are summarized as shown in the table 2. The flow-duration in the river is improved because Existing water supply maintains at the same time and low flow(Q355)of downstream in the river increased about 8%. In

addition, the peak discharge flow corresponding to the flood control benefit was reduced as much as about 8.5 ㎥/sec as

13-year average, and it was analyzed that the electricity generation discharge corresponding the power generation benefit increased as much as 92.5 M ㎥ in comparison with the unilateral operation. This is because the power discharge is achieved through small hydro power plant when the water for agricultural use and the water for river maintenance will be discharged, and the Blue reservoir also is the same. Finally, the 13-year average water quantity of about 11.1 M ㎥ was additionally secured.

Table 2: Comparison of Youngcheon Dam and the Blue Reservoir

Division	Water use benefit (M㎥)				Flood benefit (㎥/sec)		Plant benefit (M㎥)		Water securing (M㎥)	
	Water supply		Q_{355} (㎥/sec)		Peak discharge		Plant discharge		Reservoir volume	
	Or	S9	Or	S9	Or	S9	Or	S9	Or	S9
Annual average	120.7	120.7	1.591	1.720	77.071	68.534	94.9	187.4	39.2	50.3

CONCLUSIONS

In this study, the authors have proposed the Blue reservoir installation technique of new concept in order to secure the water resources, and the simulation of the YeongCheon dam established in HEC-ResSim was calibrated, and the effect of the proposed technique was analyzed by applying to a model.

The scenario 9 can supply the additional water (water for agricultural use + water for maintaining) of 12-year average 6.85M㎥ into the downstream river, at the same time, the water quantity for the hydroelectric power generation was increased by using of 49.21M㎥, and it was simulated that the water of the average 9.87 M㎥ can be secured in addition over the entire period. It is considered that the Blue reservoir proposed in this study will contribute to the vitalization of the local economy by better river water supply and the algae blooms occurrence reduction, the flood damage reduction of the local residents in downstream, and the offer of recreation using the secured reservoir by means of the contribution to the increase in the water bowl, the increase of the water quantity for hydroelectric power generation which is the clean energy, and the supply of the additional water in the water that has flown into the existing river.

ACKNOWLEDGEMENTS

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